Bijlage 1 Overzicht van Sleuteltechnologieën

Deze bijlage is onderdeel van het Kader Kennisveiligheid VU. In verband met landelijke ontwikkelingen zal deze lijst aan verandering onderhevig zijn en is de actuele lijst online te raadplegen. Het is raadzaam om, voor het beoordelen of er sprake is van een sleuteltechnologie, altijd de meest actuele lijst op vu.nl te raadplegen. Zie voor meer achtergrondinformatie de NWO pagina Sleuteltechnologieën.

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Categorie	Naam sleutel-technologie	Definitie	Keywords
Advanced materials	Energy materials	Energy materials omvat alle materialen die het mogelijk maken om (duurzaam opgewekte) energie op te slaan, te transporteren, efficiënt te vangen en efficiënt om te zetten naar een andere vorm of energiedrager.	Batteries, Heat batteries, Electrochemical cells, Fuel cells, Flywheel, Solar fuels, Hydrogen storage and transport, Power to Hydrogen, Power to Gas, Power to Heat, Power to Chemicals, Wind to electricity, gas or hydrogen, Molten salt, Electrolysis, Carbon Capture materials, magneto- and electro-caloric materials, Phase change materials.
	Optical, electronic, magnetic and nanomechanical materials	Optical, electronic, magnetic and nanomechanical materials omvat materialen die het hart vormen van de integrated circuits en sensortechnologie. De materialen geven functionaliteit aan communicatie toepassingen en gegevensverwerking en -opslag. Verdere miniaturisering en integratie met een vermindering van energiegebruik staat hierin centraal. Toepassingen hebben een groot frequentiebereik van dc, via akoestisch, IR, zichtbaar licht tot Röntgen-toepassingen in Radar en lithografie.	Transistors, transistor materials, dielectrics, conductors and isolators, electrical and magnetic data storage and processing, superconductors for sensing and computing, Optical sensing, Transducers and computing, IR optics, X-ray and EUV optics.
	Meta materials	Meta materials zijn kunstmatig ontworpen materialen die vanwege hun ruimtelijke structuur andere eigenschappen hebben dan de samenstellende delen. Metamaterialen onderscheiden zich door een functionaliteit die gegeven wordt door een hiërarchische structuur met verschillende lengteschalen. Dit geeft metamaterialen hun optische of mechanische eigenschappen gekoppeld aan hun macrostructuur.	Opals, Shells, Colloid-crystals, Cloaking devices, Radar absorbers, Stealth technology, Mechanical materials for static or dynamical properties, Mechatronics.
	Soft/bio materials	Soft/bio materials bestaan uit organische en polymere componenten met een divers aantal functionaliteiten door vezels, coatings en cellulaire vormen. Ze vinden onder andere toepassingen in biologische en biomedische systemen voor diagnostische en therapeutische doelstellingen.	Organic and bio-polymer materials, Polymers, Plastics, Colloids, Emulsions, Nanocarriers, Tissue engineering, Bio-inspired materials, Bio-degradable materials.
	Thin films and coatings	Thin films and coatings zijn dunne lagen materiaal, variërend van nano- tot microschaal, die worden aangebracht op diverse oppervlakten en ondergronden. Door het aanbrengen van één of meerdere van dergelijke lagen of dunne films op andere materialen of oppervlakten kunnen extra functionaliteiten aan producten worden gegeven, zoals beschermende, zelfreinigende, zelfhelende, reflecterende (voor alle straling), absorberende, elektrische-, optische of magnetische eigenschappen.	Paints, Chemical or optical protective layers (e.g. for corrosion protection), Low-friction coatings, Low-wear coatings, Low-adhesion coatings, Biocompatible coatings, Food preservation, Active and passive materials in the IC technology, Coatings for optical functionality (such as antireflection, compound mirrors), Deposition technologies including various evaporation/vapor deposition techniques, Electro spraying, Atomic Layer Deposition, Pulsed Laser Deposition.
	Construction and structural materials	Construction and structural materials omvat materialen die zorgen voor draagkracht of sterkte onder mechanische, chemische, fysieke of thermische druk. Hieronder vallen composieten die bestaan uit samengestelde materialen met glas, keramiek, hout of polymeren.	Concrete, Steel and other metallic alloys and compounds, Green steel, Wood-based composites, Cross-laminated timber, Lightweight composites (metal and polymer), Ceramics alloys, Ceramic foams, Glass ceramics, Green steel, Service life design, Sustainable and circular materials design, Recyclability.
	Smart materials	Smart materials reageren op veranderingen in de omgeving, zoals licht, warmte, vocht, druk of bacteriën. Deze materialen kunnen onder externe invloeden veranderen of zichzelf herstellen.	Responsive material, Molecular recognition, Artificial receptors, Reversible bonding, Self-assembly, Self-repair material, Supramolecular Chemistry, Stimuli responsive material, Switchable materials, self-sensing materials, Smart delivery, Shape memory materials, Self-repair materials, self-healing materials, Membranes.
Photonics and optical technologies	Photovoltaics	Photovoltaics is de technologie waarbij zonlicht middels zonnecellen wordt omgezet in elektriciteit.	Absorbers (materials), Antireflection Coatings, Collector Efficiency, Conductive Films, Conversion Efficiency, Metamaterials, Nano-photonics, Nanowires, Organic Photovoltaics, Oxide Films, Perovskite Solar Cells, Photocurrents, Semiconductor Doping, Thermophotovoltaic Conversion, Thin Film Circuits, Silicon Solar cells, Multi-Junction Solar Cells.
	Optical systems and Integrated photonics	Optical systems zijn geconstrueerde systemen om licht te breken of te weerkaatsen om bepaalde optische functies te vervullen. Zo is bijvoorbeeld communicatie mogelijk met fotonen als informatiedrager. Geïntegreerde fotonica is de technologie die verschillende fotonische functies (genereren, moduleren, detecteren, etc.) integreert in een functionele fotonische chip. Systeemintegratie is een belangrijk element in de toepassing van geïntegreerde fotonica.	Analog-optical interconnection technology, Fiber Optics Communications, Integrated Optics & systems, Integrated photonic smart antennas, Microphotonics, Nano-photonics, Optical Fiber Communication, Optical Resonators, Optical signal technology, Phase Modulation, photonic chips, Photonic Devices, Photonic Integrated Circuits, Photonic Integration Technology, Photonic phased array system, Photonic signal processing, Wavelength Filters, Biosensing, Photonic packaging, Photon Manipulation, Photon Conversion, Green ICT, Free Space optics, Fibres & Fibre Systems, Photonic Communication, Optical metrology systems, Gradient index (GRIN) lenses, Diffractive optics, Laser optics & systems, Optical System design/optomechatronics, Theoretical and applied non-imaging optics, Theoretical and applied imaging optics, Space optics, Aberration theory.
	Photonic/Optical detection and processing	Photonic/optical detection and processing omvat het opvangen en meten van fotonen en andere lichtgolven binnen het volledige frequentiespectrum (inclusief Röntgen en UV), die worden ontvangen uit onder meer beelden, gegevensverbindingen en experimenteel spectroscopisch onderzoek. Fotonische detectie houdt zich bezig met het ontwerp, de fabricage en het testen van enkelvoudige en meervoudige detectoren. Ook het meten, ontwerpen, maken, simuleren en testen van en met optische systemen valt hieronder.	Photonic Sensing, Single-Photon Detection, Anticoincidence Detectors, CCD, Image Sampling, Wavelength detectors, Integral Field Unit, Inverse Synthetic Aperture Radar, Laser radiometry, Optical Imaging, Radar Signal Processing, Signal Reconstruction, Signal Sampling, Spectral Imaging, Fibre optical systems, Fibre optic sensors, Spectroscopy, Remote sensing, Photodiodes, LIDAR, Optical metrology, Nano-photonics, Lithography, X-ray optics, EUV optics, Opto-acoustics, Electro-optics, Ptychography, Computational optics, Aspherical and freeform optics, Optical scattering, Grazing incidence optics, Freeform optics.
	Photon generation technologies	Bij photon generation technologies gaat het om het opwekken van fotonen door middel van lasers en andere lichtbronnen. De nadruk komt daarbij steeds meer te liggen op single photon generation wat onder meer belangrijk is in quantumtechnologie, high power lasers voor industrial processing en fiber lasers voor ultra korte pulsen.	Optical Lasers, Atom Lasers, Entangled photon generation, Light emitting diode, Microchip laser, Multi-photon generation, Nano-photonics, Optical fiber dispersion, Optical fiber lasers, Organic Lasers, Organic light emitting diode, Photon pair generation, Photonic microwave, Quantum dot, Single photon emitters, Single photon generation, Solar-pumped Lasers, Triple-photon generation, Waveform generation, Quantum Dot LEDS, Perovskite LED, Laser-driven light sources, Solid state lighting, VCSEL, XUV, X-ray sources.

Quantum technologies	Quantum computing	Quantum computing bestaat uit verschillende lagen, waaronder onder andere de hardware, virtual en software, en maakt gebruik van de wetten van de quantummechanica om problemen op te lossen die te complex zijn voor klassieke computers. Er wordt onderscheid gemaakt tussen dedicated quantumcomputers, algemene (universal) quantumcomputers en hybride vormen. Een dedicated quantumcomputer kan maar één specifiek optimalisatievraagstuk oplossen en een algemene (universal) quantumcomputer heeft miljoenen quantum bits nodig om alle type vraagstukken aan te kunnen. Een hybride vorm is de combinatie van een quantum computer met een High Performance Computer.	Cluster State, Cooling Capacity, Quantum Cables, Quantum Hardware, Quantum Algorithms, Quantum Circuits, Quantum Computation, Quantum Information Processing, Quantum Software Technology, Quantum Optics, Semiconductors, Superconducting Quantum Computing, Superconducting Resonators, Scalable Quantum I/O, Quantum materials, Neutral Atom Quantum Computing, Quantum software, Quantum materials, Quantum Hall effect, Quantum entanglement, Quantum simulators.
	Quantum communication	Binnen Quantum comminucation worden quantum- toestanden op verschillende plaatsen in het netwerk, zowel via grondnetwerken als satellietnetwerken, met elkaar verbonden, zodat quantuminformatie kan worden verstuurd. Quantum communication is extreem veilig omdat (ongewilde) tussentijdse metingen (onderschepping) de quantumtoestand merkbaar verandert.	Quantum Channel, Quantum Communication, Quantum Computation, Quantum Key Distribution, Cryptology technologies, Quantum Information, Quantum Optics Quantum Teleportation, Quantum Internet, Quantum memory, Quantum repeaters, Quantum integrated photonics, Post Quantum Crypto.
	Quantum Sensing	Quantum sensing behelst de technologie van het toepassen van quantumprincipes om meetnauwkeurigheid te bereiken die nauwkeuriger en gevoeliger is dan conventionele sensoren	Nanomechanical Quantum Systems, Quantum metrology, Quantum sensor, Inertial sensors, atomic clocks, Quantum Magnetometer, Quantum testbed, Advanced Optical technologies, superconducting and magnetic materials, topological insulators.
Digital and information technologies	Artificial intelligence	Artificial intelligence (AI) is een systeemtechnologie die erop gericht is om gedrag door machines te realiseren dat lijkt op natuurlijke intelligentie. Artificial intelligence omvat verschillende leerstrategieën. Bij supervised machine learning is het model/algoritme in staat classificatie of predictie te doen op basis van een test dataset en bijbehorende labels. Bij unsupervised learning maakt het algoritme deze categorisatie zonder gebruik te maken van bestaande labels. Bij reinforcement learning leert het algoritme over de beste strategie op basis van interactie met de omgeving. Deep learning staat toe problemen van hogere complexiteit en abstractie op te lossen. In toenemende mate worden voor AI hybride vormen ontwikkeld waarin mens en AI samenwerken.	Deep learning, Supervised Machine learning, Unsupervised Machine learning, Autonomous decision making, Autonomous systems, Context awareness, MachineReasoning, Neural networks, Neuroevolution , Reinforcement learning, Reasoning, Swarm Intelligence, Robotic Process Automation, Turingtest, Hybrid AI, Symbolic reasoning, Natural language processing, Large scale AI models, Speech recognition, Neuromorphic computing.
	Data science, data analytics and data spaces	Data science, analytics en data spaces (data ecosystems) betreft alle aspecten van het verzamelen, beheren, ontsluiten, delen en analyseren van data om waarde te creëren. Het data ecosysteem bevat gecentraliseerde en gedistribueerde data bases als ook federatieve oplossingen voor data delen. Voor analyse en waarde creatie moet deze data FAIR zijn, als ook moeten er afspraken stelsels bestaan over gebruik, toegang, en waarde van de data. Gegevens kunnen gestructureerd of ongestructureerd zijn, statisch of dynamisch, en gegevens kunnen zeer heterogeen zijn. De geëxtraheerde waarde kan de vorm hebben van voorspellingen, geautomatiseerde beslissingen, modellen die zijn geleerd uit gegevens of visualisaties die inzicht geven in de gegevens.	Data spaces, Data bases, Data lakes, Federated architecture, FAIR data (Findability, Accessibility, Interoperability, and Reusability), Data sharing, Autonomous analytics, Context awareness, Data as a Service (DaaS), Data accuracy, Data confidentiality, Data mining, Data science, Distributed computing, Machine learning, Pattern mining, Visual analysis, Information retrieval, Process mining, Geospatial data analytics, Text analysis, Natural language processing, Data collection, Data integration, Data cleaning, Human-Data Interaction.
	Cyber security technologies	Cyber security technologies om relevante digitale risico's tot een aanvaardbaar niveau te reduceren. Dit omvat ook het omgaan met risico's op schade of uitval van digitale systemen en de beschikbaarheid, integriteit en vertrouwelijkheid van gegevens. Technologieën zijn gericht op het voorkomen van cyberincidenten en - wanneer cyberincidenten zich hebben voorgedaan - deze te ontdekken, schade te beperken en herstel eenvoudiger te maken.	Confidentiality, Integrity, Availability, Socio-technical systems, (post quantum) Encryption, Privacy and data protection, Secure computing, Digital identity, Identity management, Vulnerabilities, Malware, DDOS, Ransomware, Secure networks, OT/IT security, Security by design, Privacy by design, Hardware security, Platform security, Software security, Data security, Cyber espionage.
	Software technologies and computing	Software technologies and computing richt zich op het ontwikkelen van methoden en technieken voor software zodat software bruikbaar en betrouwbaar is en blijvend onderhoudbaar. Daarbij is de trend enerzijds dat technologieën in toenemende mate gedistribueerde architecturen ondersteunen. Belangrijke voorbeelden daarvan zijn blockchains met het oog op decentralised trust systems, alsook cloud, edge, grid, highperformance en mobile computing. Anderzijds worden nieuwe programmeertalen, ontwikkelmethoden en testomgevingen steeds dominanter, om het hoofd te kunnen blijven bieden aan strengere kwaliteitseisen en verhoogde snelheid van innovatie.	Ledger technologies, Immutable ID, File sharing, Crypto currencies, Metaverse, Software Engineering, Cloud model, Data as a Service, Storage as a Service (SaaS), Data centres, Virtualization, Virtual machines, Distributed computing, Distributed Cyber Physical Systems, Fog computing, General-purpose computing, Graphics processing units (GPGPU), High performance computing cluster (HPCC), Parallel computing, Mobile cloud, Identity management, Domain- Specific Languages, Quantum computing, AI-based software testing, Low-Code platforms, Autonomous systems, Control distribution, Software Verification, Software Repository Analysis, Software Verification, Legacy Renovation, Model-Driven Engineering, Programming languages, Resource modeling, discovery, and management, Open source, Holistic system engineering, Responsible and sustainable computer ecosystems, Digital continuum: IoT to Edge to Cloud, Memory and storage technologies, Hardware and software co-design, System monitoring, testing, and benchmarking, Serverless and containerization.
	Digital Connectivity Technologies	Digital connectivity technologies zal zorgen voor nieuwe generatie draadloze en vaste netwerken die de grotere vraag naar capaciteit aankunnen, die robuust en flexibel zijn, en die efficiënt met energie en materialen omspringen. Veel van deze netwerken zullen programmeerbaar zijn om optimaal tegemoet te kunnen komen aan de grote diversiteit aan eisen vanuit applicaties. Te denken valt aan zeer grote bandbreedte voor netwerken in high performance computing, zeer lage latency netwerken voor autonoom rijden en industriële toepassingen, en zeer sterke beveiliging voor financiële- en overheidssectoren.	5G, 6G, Network slicing, Network Virtualization, LaserSatCom, Fiber infra, Edge Infra, Intelligent/deep connectivity, Zeekabels, IoT, logical connectivity protocols, (data link, network, transport, session), Novel multiple access (SDMA, NOMA), Cross-layer optimization, Smart networks and services, Semantic communication, Tactile internet, Digital communication networks, In-network computing, Digital and programmable infrastructure, Zero-latency networking, Optical communication, Photonics, Quantum networks, Quantum communication.
	Digital Twinning and Immersive technologies	Digital Twinning and Immersive technologies zijn een digitale representatie van fysieke processen en systemen ten behoeve van digitale, autonome productie, analyse, en optimalisatie. Digital twins worden onder andere gebruikt voor engineering en fabrication technologies voor modelleren van machines en processen, in Life Science and Health en medtech voor een digitale tegenhanger van een organisme (zoals de mens). Digital twins ontwikkelen zich in toenemende mate tot meer interactieve en dynamische systemen (die bijvoorbeeld processen kunnen aan- en bijsturen). Digital twins bouwen voort op een aantal andere digitale technologieën zoals computing, connectivity and communication technologies, cloud en IoT netwerken, data science voor het delen en analyseren van data, AI voor predictie en immersive technologies voor de creatie van realistische ervaringen en optimale interactie met de kunstmatige, gesimuleerde omgeving. Immersive technologies transformeren ervaringen naar een realistischer niveau door het virtueel samen brengen van het zicht (beeld), het geluid en zelfs de aanraking van gebruikers.	Industry 4.0, Smart Industry, Virtual devices, Virtual product, Virtual worlds, Virtual human, Digital technical intelligence, Real-time and embedded systems, Physical systems, Cyber-physical systems, Predictive modeling, Optimization, Simulation, Digital interaction, Digital Engineering, performance monitoring, performance optimization, predictive maintenance, Mixed, virtual and extended reality (AR/MR/ VR/XR), Social XR, Social touch, Virtual worlds, Human-machine interaction, Teleoperation, Digital data spaces, Holographic/volumetric media, Rendering engine, Haptics, Cybernetics, Metaverse, Brain-computer interaction, Human augmentation, Sensing, AI, Data science, Software technologies and computing.
	Neuromorphic technologies	Neuromorphic technologies richten zich op bio-geïnspireerde hardware voor het energie-efficiënt verwerken van informatie. Neuromorphic kan betrekking hebben op directe modellen van biologische structuren zoals neuronen en synapsen, maar ook op digitale en/of analoge implementaties van kunstmatige neurale netwerken zoals gebruikt in machine learning en robotics. Hardware implementatie van neuromorphic technologies kan gerealiseerd worden door onder andere memristors, spintronic devices en complexe nanomateriaal netwerken.	Neuromorphic Computing, Unconventional Computing, In-matter Computing, AI Hardware, Memristors, Cognitive Matter, Artificial Synapses, Artificial Neurons, Spiking Neural Networks.
Chemical technologies	(Bio)Process technology, including process intensification	(Bio)Process technology, including process intensification richten zich op het optimaal, stabiel en veilig inrichten van (groene) chemische productieprocessen. Hieronder vallen zaken als: schaalbaarheid, warmte-integratie, veiligheid, optimale downstream processing, ruimtebeslag en kostenefficiëntie. Synthese is naast seperation technologies een essentieel onderdeel van chemische productieprocessen. Een belangrijke trend is om in productieprocessen meer gebruik te maken van groene (duurzame) grondstoffen, bijproducten en afvalstromen te beperken en deze zoveel mogelijk te hergebruiken en recyclen.	Process systems engineering, Process integration, Synthesis, Photoredox synthesis, Protein synthesis (e.g. CO2 -to-protein), (chemical) Recycling, Polymerization, De-polymerization, Pyrolysis, Green chemistry, Renewable feed stock, Bioreactor(s), Bioprocessing, Fermentation, Enzymatic conversion, biomaterials, biochemicals, Bio-hydrogen, Metabolic engineering, Green solvents, Non-toxic chemicals, Nutraceuticals.

	(Advanced) Reactor engineering	(Advanced) Reactor engineering faciliteert chemische reacties op grote en op (zeer) kleine schaal. Reactordesign (zoals bijvoorbeeld microreactordesign) is hierbij van belang.	Process intensification, fluid mechanics, multi-phase reactants, Advanced heat and mass transfer concepts, Modelling, Lab-on-a-chip, process-on-a-chip, Reaction telescoping, Microchannels, Photochemistry, Micro/milli channels, electricity-driven chemical reactors.
	Separation technology	Separation technology betreft het tot een voor de toepassing benodigde zuiverheid of goede functionaliteit opwerken van grondstoffen, welke veelal verwerkt zijn in complexe producten. Daarbij wordt gebruik gemaakt van meso- en microstructuren en wordt gestreefd naar het behoud van of het bereiken van specifieke structuren. Ook in de milieu-technologie speelt Separation technology een belangrijke rol. Scheiding kan plaatsvinden op basis van chemische of fysische eigenschappen van grondstoffen en producten.	Drying, Dehydration, Air purification, Fuel purification, Water purification, Gas filter, Liquid filter, Filter membranes, Membrane filtration, Vapor filter, Distillation filter, Extraction filter, Crystallization filter, Reactive distillation, Metal recycling, Depolymerization
	Catalysis	Catalysis maakt het proces van omzetten van grondstoffen in andere producten efficiënter: minder energie voor een specifieke chemische reactie, of bevordering van omzetting naar een specifiek eindproduct. Ook stelt catalysis ons in staat om 'slimmere' producten uit andere grondstoffen te maken (bijvoorbeeld de inzet van enzymen als katalysator om voedselvariaties zoals kunstvlees te maken, of om methanol en suikers als grondstof te gebruiken). Er kan onderscheid gemaakt worden in homogene-, heterogene en bio-katalyse.	Biocatalysis, Homogeneous catalysis, Heterogeneous catalysis, Single-atom catalysis, Green Chemistry Technology, Catalysis for (advanced) Recycling, Catalysis for (de-)polymerization, Nanoreactors, Cross coupling, Electrocatalysis, Catalytic DNA, Photocatalysis, Reaction intermediates, Catalytic oxidation, Chemical activation, (de)Hydrogenation, Polymerization, isomerization.
	Analytical technologies	Analytical technologies omvat geavanceerde analyse-, detectie- en meetmethoden om grondstoffen, tussenproducten of eindproducten, (in vaste, vloeistof of gasvorm te onderzoeken op onder andere zuiverheid, materiaaleigenschappen en toxiciteit. Daarbij is er sprake van dynamische analyse van structuur op verschillende schaalniveaus (1 nm – 1 mm).	Analytical separation, Spectroscopy, Chromatography, Microscopy, Sequencing, Magnetic resonance, Mass Spectrometry, Chromatography, Ray absorption, Xray, Tomography, non-target analysis.
	Electricity-driven chemical reaction technologies	Electricity-driven chemical reaction technologies sluiten aan bij de trend om bestaande chemische processen te elektrificeren om daarmee emissies te reduceren. Elektriciteit kan zowel direct als indirect in een chemische reactie worden ingezet, en gericht zijn op de aard van de energietoevoer of het reactiemechanisme. Voorbeelden van dat laatste zijn elektrochemische of fotochemische processen die respectievelijk elektrische energie of fotonen inzetten om chemische verbindingen te maken of te breken en grondstoffen in het reactieproces te sturen naar specifieke eindproducten.	Electrical naphtha cracking, Electrical reforming, Electrochemistry (including hydrogen production), Electrochemical processes, CCU, Bio(electro)chemical processes, Electro-chemical fermentation, Energy conversion and storage, Fuel Cells, Energy carriers, Batteries, Plasma technologies, Hydrometallurgical metals recycling, Power-to-x technologies.
Nanotechnology	Nanomanufacturing	Nanomanufacturing omvat fabricageprocessen om structuren en functionaliteit op nanoschaal te bouwen. Nanomanufacturing heeft raakvlakken met de fabricage van nanomaterialen zelf. (zie hieronder). Zo is ook voor Nanomanufacturing het karakteriseren en (theoretisch) ontwerpen van materialen van belang, in combinatie met de instrumenten/methodes om nanomaterialen te maken of te laten groeien. Daarbij worden computational methodes ingezet. Tevens omvat Nanomanufacturing het integreren van nanodevices in producten, waarbij ook de opschaling van fabricage van één device naar grote aantallen aan de orde is. Tenslotte is het aanbrengen van nano-coatings op grote oppervlakten (depositie technologie) een belangrijke uitdaging in de productie van onder meer wafers en zonnepanelen. Een aandachtspunt tijdens Nanomanufacturing is vervuilingbeheersing. Alle aspecten van nanotechnologie (en quantumtechnologie) kunnen worden verstoord door aanwezigheid van nanodeeltjes of laagjes vervuiling zo dun als een paar atoomlagen. Deze verstoringen moeten worden voorkomen of verwijderd. Hiervoor is kennis nodig van ontstaan, transport, detectie, en verwijdering van deze vervuilingen.	Nanofabrication, Nanomaterial, Biomaterial, Nanoelectronics, Nanolithography, Selfassembly, Nano metrology and inspection, Materials by design, bio-nano devices for healthcare, defectivity, Contamination control, Deposition and coating technologies, Nanoscopy, Nano characterization, Nano inspection.
	Nanomaterials	Nanomaterials zijn chemische stoffen of materialen die bestaan uit zeer kleine deeltjes van verschillende vorm en grootte (< 100nm, evenals 2D-materialen). Ze komen voor in de natuur, kunnen een incidenteel product van menselijke activiteit zijn (bv. lasrook) of doelbewust worden vervaardigd en gemanipuleerd om nieuwe kenmerken te vertonen of een specifieke structuur aan oppervlakten te geven. Voorbeelden zijn een grotere sterkte, chemische reactiviteit of geleidingsvermogen in vergelijking met hetzelfde materiaal zonder nanoschaalkenmerken14. De vervaardiging van dergelijke materialen en nanogestructureerde oppervlakten vereist instrumenten en methodes om deze te maken of te laten groeien en om het resultaat daarvan op nanoschaal te inspecteren en karakteriseren (zie ook Nanomanufacturing). Bij het ontwikkelen van nieuwe Nanomaterials worden computational methodes steeds meer ingezet, bijvoorbeeld ten behoeve van 'materials by design', waarin gewenste eigenschappen van de Nanomaterials het vertrekpunt vormen.	2D materials, Nano-coatings, Nanostructured (functional) surfaces, Nanoparticles, Nanotube, Nanosheets, Nanofluids, Nanorods, Nanofibers, Quantum dots, Electro-magnetic functionality (quantum materials), Nanocomposites, Nanocrystalline materials, Nanostructured films, Membranes, Bio-nano materials, Computational materials synthesis, High entropy alloys, Designer materials, Materials by design, Nanoscale meta-materials, Nano materials for neuromorphics, Nanotribological coating and structures, Colloids.
	Functional devices and structures (on nanoscale)	Functional devices and structures (on nanoscale) omvat het combineren en integreren van elektronische, magnetische, nano-mechanische, optische, bio of quantum principes in componenten of apparaten die materie op atomaire of moleculaire schaal kunnen manipuleren. De nanodimensies en materiaaleigenschappen maken complexe schakelingen en arrays mogelijk.	Nanoelectronics, Spintronics, Nano-photonics, Nanoelectromechanical devices, Quantum-nanodevices, Semiconductor devices, Logic devices, Microelectronics, Micro- and nano mechanics, Molecular motors, Transistors, Nanoelectromechanical oscillators, Nanolithography, Neuromorphic nanodevices, Nanotribological coatings and structures.
	Micro- and nanofluidics	Micro- and nanofluidics omvat de technieken voor het bestuderen, waarnemen en controleren van het transport en de reactie van vloeistoffen in structuren met een micro- of nanometerschaal. Vloeistoffen in deze structuren gedragen zich anders dan in macrostructuren.	Nanofluidics Chips, Lab on a Chip, Organ-on-a-chip, Point-of-care bioanalysis, Nanofluidic devices, Bio-MEMS, Biosensors, Nanochannels, Nanoreactors, In-chip Nanocooling, Nanolithography.
	Nanobiotechnology / Bionanotechnology	Nanobiotechnology/Bionanotechnology omvat de toepassing van nanotechnologie op het bestuderen van het leven de nanoschaal om inzichten te krijgen in bijvoorbeeld cellen en virussen. Die inzichten zijn onder andere van belang in medische toepassingen, sensoren, life-inspired materialen, synthetische cellen. Bionanotechnology is de toepassing van moleculaire biologie op nanotechnologie waarbij materialen en apparaten op nanoschaal worden vervaardigd.	Drug Delivery, Tissue Engineering, Biocompatibility, Biosensors, Nanobiotechnology, Protein, Nanoscale, Nanoparticle, Nanomaterial, Biosensing, Cellular Biophysics, Biophysical Processes, Molecular biophysics, Nanoscale biomimicry, Biomimetic antibacterial surfaces, Biomolecule characterization, Vaccine technology, Synthetic cell technology, Artificial meat.
Life science and biotechnologies	Biomolecular and cell technologies	In den brede omvatten biomoleculaire technologieën het in kaart brengen, meten en gebruiken van moleculen zoals DNA, RNA, en eiwitten/metabolieten. Een belangrijke groep technologieën wordt gevormd door de X-omics (Genomics/transcriptomics/ proteomics/metabolomics/glycomics, microbiomics, exposomics) die tot doel hebben het geheel van biologische entiteiten van een bepaald type, zoals het genoom, het proteoom, het metaboloom, het microbioom of het exposoom van een organisme te kwantificeren en te karakteriseren. Zo kunnen tot op het individu toegespitste therapeutische of ziektevoorkomende strategieën worden ontwikkeld (personalized medicine), of kan een gewas of dier worden ontwikkeld dat bestand is tegen abiotische stress (bijvoorbeeld als gevolg van extreme klimaatomstandigheden) en biotische stress (als gevolg van aantasting door ziekten en plagen). Een tweede groep betreft gene editing/precise genetic engineering technieken die de mogelijkheid bieden het DNA van een organisme (humaan, dier, plant, microbe) op zeer specifieke plaatsen te veranderen. Een derde groep omvat stamceltechnologie (ook bekend als regeneratieve geneeskunde), bevordert de herstelreactie van ziek, disfunctioneel of beschadigd weefsel met behulp van stamcellen. Regeneratie bij gewassen is ook een vorm van stamceltechnologie, waarbij uit een enkele cel een volledig nieuwe plant ontstaat (ten behoeve van vermeerdering maar ook eliminatie van plantenvirusziektes). Synthetische celtechnologie is in opkomst als een techniek die de structuur en functie van levende cellen vanaf nul nabootsen (minimal cell) met doel de opbrengst en kwaliteit van het product te verhogen en bijproducten te voorkomen wat de veiligheid verhoogt. Ook organoïden zijn sterk in opkomst: drie- dimensionale miniatuurversies van organen die gekweekt worden uit stamcellen.	Genome analysis, Genomic engineering, Multi-omics, Integrated omics, Biomarkers, Metabolomics, Transcriptomics, Proteomics, Glycomics High-throughput sequencing, Next generation sequencing, Machine learning, gen-functie voorspelling, Proteome/ Genome/Metabolome analysis, Analytical chemistry, Exposome, Microbiome, Molecules by design, Cell Surface Display Techniques, Biomarker discovery. CRISPR-Cas, Single gene disorders, Ethics, DNA repair, Gene therapy, Genome editing, New Genomic Techniques, Precision Breeding, Synthetic Biology, Genetic Modification, Personalized medicine., Personalized food, Biofortification. Regenerative medicine, Organ transplantation, Tissue repair, Gene therapy, Targeted gene repair, Induced Pluripotent Stem Cells, In vitro Regeneration, Artificial cells, Minimal cells, Cell therapy, Synthetic biology, Metabolic Engineering, Organoids, Synthetic stem cells.
	Biosystems and organoids	Biosystemen omvat een aantal verschillende componenten. In vitro systemen en met name organoïden spelen in de medische sector een steeds belangrijker rol. Nanomedicine betreft de toepassing van nanotechnologie ten behoeve van gezondheid. Die toepassingen vinden vooral plaats in biochips en biosensoren voor diagnose of	Nanotechnology, Nanomaterials, Nanoelectronics, Nanofluids, Metabolic engineering, Bioreceptor, transducer, Analytes, Microfluidics, Biosensing, Lab-on-a-chip, Organ-on-a-chip, Microfluidics, Biosensors, Glucose Sensors,

		functionele karakterisatie van complexe (voedings) mengsels. Ook speelt nanotechnologie een belangrijke rol in organen-op-chips (OoC's): systemen met gemodificeerde of natuurlijke miniatuurweefsels die in microfluïdische chips zijn gekweekt die representatief zijn voor gezonde of ongezonde humane weefsels. Andere biosysteemtechnologieën zijn van belang in de industrie en voor milieutoepassingen zoals bioremediation. Het gaat hier om biosystemen als microbiële consortia (darm, bodem enz), waterplanten, biofilms, symbiotische systemen, en voor productie via planten (vertical farms, algen).	Immunosensors, Analytic Equipment. Organoids, Primary Cell Culture, Tissue Scaffolds, Bioprinting, stem cell technology, Microelectronics, Microfabrication, Organ and/or disease models, Personalized medicine, Patient-specific Modeling, Microbia(l consortia, Biofilms, Symbiotic systems.
	Biomanufacturing and bioprocessing	Biomanufacturing en bioprocestechnologie zijn onder meer van belang in de industriële- en de voedsel-biotechnologie die gebruik maakt van enzymen en micro-organismen om bio-gebaseerde producten te maken: sectoren als chemie, medicijnproductie, levensmiddelen en diervoeder, gezondheidszorg, papier en pulp, textiel biopolymeren en bio-energie. Een voorname rol in deze bioprocestechnologie wordt gespeeld door biokatalyse: het gebruik van natuurlijke stoffen, waaronder enzymen uit biologische bronnen of hele cellen, om chemische reacties te versnellen. Veel aandacht is er voor het optimaliseren van (industriële) productiecondities zoals teeltcellen, kweeksystemen en fermentoren. Bioprocessing heeft ook belangrijke milieutoepassingen van afvalwaterzuivering (en andere biologische zuiveringstechnieken). Een zich snel ontwikkelende high-tech tak van bioproductie is biofabrication: de productie van complexe biologische producten uit grondstoffen zoals levende cellen, matrices, plantaardige biomassa (inclusief reststromen), biomassa uit schimmels (bijvoorbeeld mycelium van paddenstoel-vormende schimmels), biomaterialen en moleculen mede gestimuleerd door de ontwikkeling van 3D-fabricagetechnologieën.	Microorganisms, Bio-based products, Bio-Based Building blocks, Biopolymer fibres, Biodegradable plastics, Biofuels, Lubricants, Industrial enzymes, Antibiotics, Vitamins, Amino acids and other fine chemicals, Pharmaceuticals, Vaccines or vaccine components, Diagnostics, Greenhouse gas emissions, Synthetic Biology, Metabolic engineering, Bio process technology. Protein Engineering, Organic solvents, Microorganism Biocatalyst, Superoxide Reductase. Biomaterials, fabrication, bioprinting, Tissue Scaffolds Tissue Engineering, Artificial organs, Patient-specific Modeling, Cell Engineering, 3D biofabrication, 3D reconstruction, tissue constructs, biological models, regenerative medicine.
	Bio-informatics	Bio informatica is de toepassing van informatiewetenschappen op biologische processen. Recent heeft de bio-informatica een belangrijke impuls gekregen door ontwikkelingen in machine learning en AI die het mogelijk maken betekenisvolle verbanden te leggen uit zeer grote datasets. AI maakt het mogelijk veel sneller inzicht te krijgen in bijvoorbeeld de 3D-structuur van eiwitten, complexe multigen processen in organismen, de risicofactoren en oorzaken van ziekten of de verwachte respons op medische ingrepen of medicatie bij dier of mens of van een gewas onder biotisch/ abiotische stres. Belangrijk is ook het verkrijgen van een overzicht van de allelische variatie en de variatie in fenotypes, en de analyse van complexe netwerken, inclusief niet-biologische- en omgevingsdata (ecosysteem).	Functional genomics, Structural genomics, Genome analysis, Genome-wide association studies, DNA Microarrays, Metabolome analysis, Medical Informatics, Systems biology, Artificial Intelligence, Machine learning, DNA/RNA/protein sequencing, Computational biology, Personalized medicine, Genetic diversity, Directed evolution.
Engineering and fabrication technologies	Sensor and actuator technologies	Sensor and actuator technologies omvat zowel sensoren als actuatoren. Een sensor zet bepaalde fysieke gebeurtenissen om in signalen (elektrisch, optisch). Een actuator werkt in de tegenovergestelde richting van een sensor en neemt bepaalde elektrische, thermische of optische signalen als input en zet die om in fysieke actie, bijvoorbeeld het inschakelen of positioneren van een apparaat.	Sensor networks, Actuator Networks, Optical fibre sensors, Ultrasonic sensors, Digital sensing, Internet of Things, Cyber-Physical Systems, Embedded Systems, Internet of Things, Digital Twin, Transducers, Molecular machinery; CRISPR-cas9 technology; Biotechnology; Bioengineering, Synthetic biology, Remote sensing, Plasmonics.
	Imaging technologies	Imaging technology houdt zich bezig met het genereren, verzamelen, dupliceren, analyseren, wijzigen en visualiseren van beelden (optisch en niet-optisch). In de industriële context worden beeldvormingstechnologieën vooral gebruikt voor kwaliteitscontrole, en in combinatie met kunstmatige intelligentie kunnen problemen sneller worden opgespoord op basis van zelflerende systemen. Imaging technology speelt ook een grote rol in de medische technologie.	3D imaging, Vision in the loop (visual servo), THz and far-infrared imaging, Radio imaging, X-ray imaging, Optical and infrared, Medical imaging, Molecular imaging, Image-guided intervention, Tomography, Image reconstruction, Image processing, Image analysis, Machine learning, Plasmonics, Electron microscopy, Magnetic resonance, Astro imaging.
	Mechatronics and opto-mechatronics	Mechatronics and Optomechatronics omvat zowel Mechatronica als Optomechatronica. Mechatronica betreft het integraal ontwerpen van mechanische systemen en bijbehorende besturings- en regelsystemen en combineert werktuigbouw, elektrotechniek en ICT. Optomechatronica behelst de integratie van optische technologie in mechatronische systemen. Optomechatronische systemen spelen een belangrijke rol in de productie van halfgeleiders, wetenschappelijke instrumenten, medische apparatuur en robotica.	Active and Adaptive optics, Multivariable and Robust Control, Adaptive algorithms/ Smart Optics, Free-form optics, Wavefront sensing, Telescopes, Cameras, Spectrometers, Cryogenic temperatures, Computational optics, Topology optimisation for optics and mechanics, Plasmonics, Flat-optics for new imaging systems.
	Additive manufacturing	Additive manufacturing is het proces waarbij een product wordt gemaakt door het laag voor laag op te bouwen (3D printing). Het is het tegenovergestelde van subtractieve productie, waarbij een voorwerp wordt gemaakt door een blok materiaal wordt weggesneden. (bijv. verspanen). Het omvat onder meer materiaalontwikkeling, procesontwikkeling en equipmentontwikkeling	Bioprinting, Selective Laser Sintering, Stereolithography, Biofabrication, Computer Aided Manufacturing, prototyping, 3D metal printing, Print process qualification, 3D printing for bio-degradables, for food and pharma.
	Robotics	Robotics is een interdisciplinaire integratie van informatica en engineering. Het doel van Robotics is het creëren van intelligente machines die de mens op verschillende manieren kunnen bijstaan.	Autonomous assembly and disassembly, Unstructured environment, Human-robot interaction, Self-configuration, Series of one, Customisation, Artificial intelligence, Autonomous systems, Soft robotic matter. Medical: Medical robotics, Surgical robots, Hospital robots, Rehabilitation robotics, Collaborative robots, Exoskeleton, Agro-food application, Pick and place, Drone systems, Social robotics.
	Digital manufacturing technologies	Digital manufacturing technologies zijn een belangrijke driver van productiviteitsgroei in de industrie. Het bouwt op systemen en technologieën als cyber-physical systems, digital twins, ERP systemen, robotica en AI en machine learning. In de industrie omvatten deze een digitale representatie van fysieke processen en systemen ten behoeve van digitale, schaalbare en flexibele productie. Digital twins ontwikkelen zich mede door toepassing van AI verder tot meer autonome, interactieve en dynamische productiesystemen. B2B platforms en data spaces zijn hier van belang alsmede (predictive maintenance).	Industry 4.0, Digital Technical intelligence, Real-time and Embedded Systems, Viable System Model, Embedded Systems, Cyber-Physical Systems (CPS), Cybernetics, Autonomous Systems, Computer Architecture, Predictive modeling, AR/VR, digital data spaces, Agent-based manufacturing, Predictive maintenance.
	Micro electronics	Microelectronics betreft halfgeleidercomponenten en/of sterk geminiaturiseerde elektronische subsystemen en de integratie daarvan in grotere producten en systemen. Zij omvatten de fabricage, het ontwerp, de verpakking en het testen van halfgeleidercomponenten tot systemen op microschaal die meerdere functies op een chip integreren (semicon devices). Onder deze technologie vallen ook High Frequency and Mixed Signal Technologies (combineren van digitale en analoge signalen uit verschillende bronnen in een geïntegreerd systeem).	Electronic Transistors, Microchips, Semiconductor Diodes, Semiconductor Manufacturing, Semiconductor Detectors, Sensor electronics, Internet of Things, Medical electronics, Computing hardware, Signal processing hardware, 5G/6G, Biomedical biochemical sensors, GPS, communication, Radar, LIDAR.
	Systems engineering	Systems engineering is een methodische, multidisciplinaire aanpak voor het ontwerp, de realisatie, het technisch beheer, de exploitatie en de buitengebruikstelling (design for recycling) van een systeem gedurende de levenscyclus. Het gaat om een (complex) systeem dat alle elementen omvat die nodig zijn om (optimaal) te kunnen produceren en oplossingen te realiseren: hardware, software, uitrusting, faciliteiten, personeel, processen en procedures.	Complex systems, AI, Machine learning, Industrial engineering, Production Systems Engineering, Process systems engineering, Mechanical engineering, Software engineering, Electrical engineering, Cybernetics, Organizational studies, Project management, Power electronics, Knowledge Based Engineering, Multi-disciplinary Optimization.

Appendix 1: Overview of key technologies

This appendix is part of the VU Knowledge Security Framework. Due to national developments, this list will be subject to change and the current list can be consulted online. Before assessing whether a key technology is involved, it is advisable to always consult the most up-to-date list on vu.nl. For more background information, see the NWO Key Technologies page.

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Category	Key technology	Definition	Keywords
Advanced materials	Energy materials	Energy materials include all materials that make it possible to store, transport, efficiently capture and efficiently convert (sustainably generated) energy.	Batteries, Heat batteries, Electrochemical cells, Fuel cells, Flywheel, Solar fuels, Hydrogen storage and transport, Power to Hydrogen, Power to Gas, Power to Heat, Power to Chemicals, Wind to electricity, gas or hydrogen, Molten salt, Electrolysis, Carbon Capture materials, magneto- and electro-caloric materials, Phase change materials.
	Optical, electronic, magnetic and nanomechanical materials	Optical, electronic, magnetic and nanomechanical materials are materials used in integrated circuits and sensor technology. These materials make it possible for communication applications to function and for data to be processed and stored. Further miniaturisation and integration and reducing energy consumption are central to this. Applications have a wide frequency range, from DC, acoustic, and infrared to visible light and X-ray applications in radar and lithography.	Transistors, transistor materials, dielectrics, conductors and insulators, electrical and magnetic data storage and processing, superconductors for sensing and computing, Optical sensing, Transducers and computing, IR optics, X-ray and EUV optics.
	Metamaterials	Metamaterials are artificially designed materials that have different properties from their constituent parts due to their spatial structure. Metamaterials are distinguished by functionalities created by a hierarchical structure with different length scales. These give metamaterials their optical or mechanical properties, which are linked to their macrostructure.	Opals, Shells, Colloid-crystals, Cloaking devices, Radar absorbers, Stealth technology, Mechanical materials for static or dynamic properties, Mechatronics.
	Soft materials/biomaterials	Soft materials/biomaterials consist of organic and polymeric components with a diverse range of functionalities offered by fibres, coatings and cellular shapes. They can be applied in biological and biomedical systems for diagnostic and therapeutic purposes.	Organic and bio-polymer materials, Polymers, Plastics, Colloids, Emulsions, Nanocarriers, Tissue engineering, Bio-inspired materials, Bio-degradable materials.
	Thin films and coatings	Thin films and coatings are thin layers of material, ranging from the nano to the micro scale, applied to various surfaces and substrates. By applying one or more such layers to other materials or surfaces, products can be given protective, self-cleaning, self-healing, reflective (for all radiation), absorbing, electrical, optical or magnetic properties.	Paints, Chemical or optical protective layers (e.g. for corrosion protection), Low-friction coatings, Low-wear coatings, Low-adhesion coatings, Biocompatible coatings, Food preservation, Active and passive materials in the IC technology, Coatings for optical functionality (such as antireflection, compound mirrors), Deposition technologies including various evaporation/vapor deposition techniques, Electro spraying, Atomic Layer Deposition, Pulsed Laser Deposition.
	Construction and structural materials	Construction and structural materials are materials that provide load-bearing capacity or reinforcement under mechanical, chemical, physical or thermal pressure. This includes glass, ceramic, wood and polymer composites.	Concrete, Steel and other metallic alloys and compounds, Green steel, Wood-based composites, Cross-laminated timber, Lightweight composites (metal and polymer), Ceramic alloys, Ceramic foams, Glass ceramics, Green steel, Service life design, Sustainable and circular materials design, Recyclability.
	Smart materials	Smart materials respond to environmental factors (such as light, heat, moisture, pressure and bacteria), for instance by repairing themselves.	Responsive material, Molecular recognition, Artificial receptors, Reversible bonding, Self-assembly, Self-repair material, Supramolecular Chemistry, Stimuli responsive material, Switchable materials, self-sensing materials, Smart delivery, Shape memory materials, Self-repair materials, self-healing materials, Membranes.
Photonics and optical technologies	Photovoltaics	Photovoltaics is technology that converts sunlight into electricity through solar cells.	Absorbers (materials), Antireflection Coatings, Collector Efficiency, Conductive Films, Conversion Efficiency, Metamaterials, Nano-photonics, Nanowires, Organic Photovoltaics, Oxide Films, Perovskite Solar Cells, Photocurrents, Semiconductor Doping, Thermophotovoltaic Conversion, Thin Film Circuits, Silicon Solar cells, Multi-Junction Solar Cells.
	Optical systems and integrated photonics	Optical systems are engineered to refract or reflect light to perform certain optical functions, making it possible to communicate using photons as information carriers, for example. Integrated photonics is the technology that integrates various photonic functions (generation, modulation, detection, etc.) into a functional photonic chip. System integration is an important element in the application of integrated photonics.	Analog-optical interconnection technology, Fiber Optics Communications, Integrated Optics & systems, Integrated photonic smart antennas, Microphotonics, Nano-photonics, Optical Fiber Communication, Optical Resonators, Optical signal technology, Phase Modulation, photonic chips, Photonic Devices, Photonic Integrated Circuits, Photonic Integration Technology, Photonic phased array system, Photonic signal processing, Wavelength Filters, Biosensing, Photonic packaging, Photon Manipulation, Photon Conversion, Green ICT, Free Space optics, Fibres & Fibre Systems, Photonic Communication, Optical metrology systems, Gradient index (GRIN) lenses, Diffractive optics, Laser optics & systems, Optical System design/optomechatronics, Theoretical and applied non-imaging optics, Theoretical and applied imaging optics, Space optics, Aberration theory.
	Photonic/optical detection and processing	Photonic/optical detection and processing involves the capture and measurement of photons and other light waves within the full frequency spectrum (including X-ray and UV) from images, data links, experimental spectroscopic research results and other sources. Photonic detection comprises the design, manufacture and testing of single and multiple detectors and optical systems, as well as measurements and simulations involving optical systems.	Photonic Sensing, Single-Photon Detection, Anticoincidence Detectors, CCD, Image Sampling, Wavelength detectors, Integral Field Unit, Inverse Synthetic Aperture Radar, Laser radiometry, Optical Imaging, Radar Signal Processing, Signal Reconstruction, Signal Sampling, Spectral Imaging, Fibre optical systems, Fibre optic sensors, Spectroscopy, Remote sensing, Photodiodes, LIDAR, Optical metrology, Nano-photonics, Lithography, X-ray optics, EUV optics, Opto-acoustics, Electro-optics, Ptychography, Computational optics, Aspherical and freeform optics, Optical scattering, Grazing incidence optics, Freeform optics.
	Photon generation technologies	Photon generation technologies generate photons using lasers and other light sources. The focus is increasingly on single photon generation, with important applications ranging from quantum technology to high-power lasers for industrial processing and fibre lasers for ultra short pulses.	Optical Lasers, Atom Lasers, Entangled photon generation, Light emitting diode, Microchip laser, Multi-photon generation, Nano-photonics, Optical fibre dispersion, Optical fibre lasers, Organic Lasers, Organic light emitting diode, Photon pair generation, Photonic microwave, Quantum dot, Single photon emitters, Single photon generation, Solar-pumped Lasers, Triple-photon generation, Waveform generation, Quantum Dot LEDS, Perovskite LED, Laser-driven light sources, Solid state lighting, VCSEL, XUV, X-ray sources.

Quantum technologies	Quantum computing	Quantum computing consists of several layers, including hardware, virtual and software. It uses the laws of quantum mechanics to solve problems too complex for traditional computers. There are dedicated quantum computers, general (universal) quantum computers and hybrids. While dedicated quantum computers can only solve specific optimisation problems, general (universal) quantum computers are able to solve any kind of problem using millions of quantum bits. A hybrid is a combination of a quantum computer and a high-performance computer.	Cluster State, Cooling Capacity, Quantum Cables, Quantum Hardware, Quantum Algorithms, Quantum Circuits, Quantum Computation, Quantum Information Processing, Quantum Software Technology, Quantum Optics, Semiconductors, Superconducting Quantum Computing, Superconducting Resonators, Scalable Quantum I/O, Quantum materials, Neutral Atom Quantum Computing, Quantum software, Quantum materials, Quantum Hall effect, Quantum entanglement, Quantum simulators.
	Quantum communication	In quantum communication, various quantum states are connected at different places in a network, both through ground and satellite networks, so that quantum information can be transmitted. Due to the fact that any (unwanted) measurements during the communication process (interceptions) noticeably change the quantum state, quantum communication is extremely secure.	Quantum Channel, Quantum Communication, Quantum Computation, Quantum Key Distribution, Cryptology technologies, Quantum Information, Quantum Optics Quantum Teleportation, Quantum Internet, Quantum memory, Quantum repeaters, Quantum integrated photonics, Post Quantum Crypto.
	Quantum sensing	Quantum sensing is technology that applies quantum principles to perform measurements that are more accurate and sensitive than those made by conventional sensors.	Nanomechanical Quantum Systems, Quantum metrology, Quantum sensor, Inertial sensors, atomic clocks, Quantum Magnetometer, Quantum testbed, Advanced Optical technologies, superconducting and magnetic materials, topological insulators.
Digital and information technologies	Artificial intelligence	Artificial intelligence (AI) is a systems technology aimed at creating machine behaviour that resembles natural intelligence. AI encompasses several learning strategies: supervised machine learning, in which the algorithm is able to make classifications or predictions based on labelled training data; unsupervised learning, in which the algorithm categorises data without using existing labels; reinforcement learning, in which the algorithm hones its strategy based on interactions with its environment; and deep learning, which makes it possible to solve problems involving higher levels of complexity and abstraction. Human-AI collaborations and hybrid working methods are becoming increasingly common.	Deep learning, Supervised Machine learning, Unsupervised Machine learning, Autonomous decision making, Autonomous systems, Context awareness, MachineReasoning, Neural networks, Neuroevolution, Reinforcement learning, Reasoning, Swarm Intelligence, Robotic Process Automation, Turing test, Hybrid AI, Symbolic reasoning, Natural language processing, Large scale AI models, Speech recognition, Neuromorphic computing.
	Data science, data analytics and data spaces	Data science, analytics and data spaces (data ecosystems) involves all aspects of collecting, managing, accessing, sharing and analysing data to create value. Examples of data ecosystems include centralised and distributed databases as well as federated data-sharing solutions. To facilitate analysis and value creation, data has to be FAIR (Findable, Accessible, Interoperable, Reusable), and there have to be agreements on using, accessing and valuing it. Data can be structured or unstructured, static or dynamic, and highly heterogeneous. It can create value in the form of predictions, automated decisions, machine-learning models and insights derived from visualisations.	Data spaces, Data bases, Data lakes, Federated architecture, FAIR data (Findability, Accessibility, Interoperability, and Reusability), Data sharing, Autonomous analytics, Context awareness, Data as a Service (DaaS), Data accuracy, Data confidentiality, Data mining, Data science, Distributed computing, Machine learning, Pattern mining, Visual analysis, Information retrieval, Process mining, Geospatial data analytics, Text analysis, Natural language processing, Data collection, Data integration, Data cleaning, Human-Data Interaction.
	Cybersecurity technologies	Cybersecurity technologies reduce relevant digital risks to acceptable levels. These include risks of damage to or failure of digital systems and the availability, integrity and confidentiality of data. Cybersecurity technologies are aimed at preventing cyber incidents and, if a cyber incident does occur, detecting them, mitigating damage and making it easier to get systems up and running again.	Confidentiality, Integrity, Availability, Socio-technical systems, (post quantum) Encryption, Privacy and data protection, Secure computing, Digital identity, Identity management, Vulnerabilities, Malware, DDOS, Ransomware, Secure networks, OT/IT security, Security by design, Privacy by design, Hardware security, Platform security, Software security, Data security, Cyber espionage.
	Software technologies and computing	Software technologies and computing comprises the development of methods and techniques that make software usable, reliable and sustainably maintainable. One trend in this area is an increasing focus on technologies that support distributed architectures, such as blockchains that facilitate decentralised trust systems, but also cloud, edge, grid, high-performance and mobile computing. Another important trend is the growing dominance of new programming languages, development methods and testing environments as a result of more stringent quality requirements and the increased speed of innovation.	Ledger technologies, Immutable ID, File sharing, Crypto currencies, Metaverse, Software Engineering, Cloud model, Data as a Service, Storage as a Service (SaaS), Data centres, Virtualisation, Virtual machines, Distributed computing, Distributed Cyber Physical Systems, Fog computing, General-purpose computing, Graphics processing units (GPGPU), High performance computing cluster (HPCC), Parallel computing, Mobile cloud, Identity management, Domain- Specific Languages, Quantum computing, AI-based software testing, Low-Code platforms, Autonomous systems, Control distribution, Software Verification, Software Repository Analysis, Software Verification, Legacy Renovation, Model-Driven Engineering, Programming languages, Resource modelling, discovery, and management, Open source, Holistic system engineering, Responsible and sustainable computing ecosystems, Digital continuum: IoT to Edge to Cloud, Memory and storage technologies, Hardware and software co-design, System monitoring, testing, and benchmarking, Serverless and containerisation.
	Digital connectivity technologies	Digital connectivity technologies will create a new generation of wired and wireless networks that can cope with an increasing demand for capacity, combining robustness with flexibility while reducing energy and material waste. Many of these networks will be programmable to meet a wide variety of requirements for different applications. Examples include very high-bandwidth networks in high-performance computing, very low-latency networks that can be used for autonomous driving and industrial applications, and highly secure networks in finance and government.	5G, 6G, Network slicing, Network Virtualisation, LaserSatCom, Fiber infra, Edge Infra, Intelligent/deep connectivity, Sea cables, IoT, logical connectivity protocols, (data link, network, transport, session), Novel multiple access (SDMA, NOMA), Cross-layer optimisation, Smart networks and services, Semantic communication, Tactile internet, Digital communication networks, In-network computing, Digital and programmable infrastructure, Zero-latency networking, Optical communication, Photonics, Quantum networks, Quantum communication.
	Digital twinning and immersive technologies	Digital twinning and immersive technologies can be used to create digital representations of physical processes and systems for the purpose of autonomous digital production, analysis and optimisation. Digital twins are used in engineering and fabrication technologies to model machines and processes, in life science and health, and in medical technologies to create digital copies of organisms (including humans). Twinning technologies are increasingly developing into more interactive and dynamic systems (which can be used to control and adjust processes, for example). Digital twins build on a number of other digital technologies, such as computing, connectivity and communication technologies, cloud and IoT networks, data science for sharing and analysing data, predictive AIs, and immersive technologies for creating realistic experiences and optimised interactions with artificial, simulated environments. Immersive technologies help create more realistic experiences by virtually bringing together visual, auditory and even tactile input.	Industry 4.0, Smart Industry, Virtual devices, Virtual product, Virtual worlds, Virtual human, Digital technical intelligence, Real-time and embedded systems, Physical systems, Cyber-physical systems, Predictive modelling, Optimisation, Simulation, Digital interaction, Digital engineering, performance monitoring, performance optimisation, predictive maintenance, Mixed, virtual and extended reality (AR/MR/ VR/XR), Social XR, Social touch, Virtual worlds, Human-machine interaction, Teleoperation, Digital data spaces, Holographic/volumetric media, Rendering engine, Haptics, Cybernetics, Metaverse, Brain-computer interaction, Human augmentation, Sensing, AI, Data science, Software technologies and computing.
	Neuromorphic technologies	Neuromorphic technologies focus on bio-inspired hardware for energy-efficient information processing. This can involve direct models of biological structures, such as neurons and synapses, as well as digital and analogue implementations of artificial neural networks as used in machine learning and robotics. Hardware implementation of neuromorphic technologies can be realised through memristors, spintronic devices and complex nanomaterial networks.	Neuromorphic Computing, Unconventional Computing, In-matter Computing, AI Hardware, Memristors, Cognitive Matter, Artificial Synapses, Artificial Neurons, Spiking Neural Networks.
Chemical technologies	(Bio)process technology, including process intensification	This technology focuses on designing optimal, stable and safe (sustainable) chemical production processes. Relevant issues include scalability, heat integration, safety, optimal downstream processing, use of space and cost efficiency. In addition to separation technologies, synthesis plays an essential role in chemical production processes. Key trends in this area are to make more use of renewable raw materials in production processes, to reduce by-products and waste streams, and to reuse and recycle waste as much as possible.	Process systems engineering, Process integration, Synthesis, Photoredox synthesis, Protein synthesis (e.g. CO2-to-protein), (chemical) Recycling, Polymerization, De-polymerization, Pyrolysis, Green chemistry, Renewable feed stock, Bioreactor(s), Bioprocessing, Fermentation, Enzymatic conversion, biomaterials, biochemicals, Bio-hydrogen, Metabolic engineering, Green solvents, Non-toxic chemicals, Nutraceuticals.
	(Advanced) reactor engineering	(Advanced) reactor engineering facilitates chemical reactions on large and (very) small scales. Reactor design (including microreactor design) plays a key role.	Process intensification, fluid mechanics, multi-phase reactants, Advanced heat and mass transfer concepts, Modelling, Lab-on-a-chip, process-on-a-chip,

			Reaction telescoping, Microchannels, Photochemistry, Micro/milli channels, electricity-driven chemical reactors.
	Separation technology	Separation technology is used to reprocess raw materials – often extracted from complex products – in order to reach the purity or functionality required for a specific application. This is done using meso- and microstructures, with the aim of maintaining or creating specific structures. Separation technology also plays an important role in environmental technology. Separation can be based on chemical or physical properties of raw materials and products.	Drying, Dehydration, Air purification, Fuel purification, Water purification, Gas filter, Liquid filter, Filter membranes, Membrane filtration, Vapor filter, Distillation filter, Extraction filter, Crystallization filter, Reactive distillation, Metal recycling, Depolymerization
	Catalysis	Catalysis makes the process of converting raw materials into other products more efficient by ensuring that less energy is needed for a chemical reaction or by enabling conversion to a specific end product. Catalysis also allows us to make 'smarter' products from other raw materials (e.g. using enzymes as catalysts to make meat substitutes, such as artificial meat, or to use methanol and sugars as raw materials). A distinction can be made between homogeneous catalysis, heterogeneous catalysis and biocatalysis.	Biocatalysis, Homogeneous catalysis, Heterogeneous catalysis, Single-atom catalysis, Green Chemistry Technology, Catalysis for (advanced) Recycling, Catalysis for (de-)polymerization, Nanoreactors, Cross coupling, Electrocatalysis, Catalytic DNA, Photocatalysis, Reaction intermediates, Catalytic oxidation, Chemical activation, (de)Hydrogenation, Polymerization, isomerization.
	Analytical technologies	Analytical technologies are advanced analytical, detection and measurement methods to assess, for instance, the purity, material properties or toxicity of raw materials, intermediates or finished products (in solid, liquid or gas form). This involves dynamic structural analysis at different scales (1 nm - 1 mm).	Analytical separation, Spectroscopy, Chromatography, Microscopy, Sequencing, Magnetic resonance, Mass Spectrometry, Chromatography, Ray absorption, X-ray, Tomography, non-target analysis.
	Electricity-driven chemical reaction technologies	These technologies have emerged in response to the trend of electrifying existing chemical processes to reduce emissions. Electricity can be used either directly (in the reaction mechanism) or indirectly (to supply energy) in a chemical reaction. Examples of the former include chemical processes that employ electrical energy or photons to make or break chemical compounds and convert raw materials into specific end products.	Electrical naphtha cracking, Electrical reforming, Electrochemistry (including hydrogen production), Electrochemical processes, CCU, Bio(electro)chemical processes, Electro-chemical fermentation, Energy conversion and storage, Fuel Cells, Energy carriers, Batteries, Plasma technologies, Hydrometallurgical metals recycling, Power-to-x technologies.
Nanotechnology	Nanomanufacturing	Nanomanufacturing processes are used to create nanoscale structures and functionality. There is an overlap between nanomanufacturing and the production of nanomaterials themselves (see below). Both involve the characterisation and (theoretical) design of materials using computational methods, relying on the same tools and methods to make or grow nanomaterials. Nanomanufacturing also includes integrating nanodevices into products, and scaling up from manufacturing single devices to large numbers. Finally, the application of nanocoatings to large areas (deposition technology) presents a major challenge in the production of wafers and solar panels. Pollution control plays an important role in nanomanufacturing, as nanotechnology (and quantum technology) can be disrupted by the presence of nanoparticles or just a few atomic layers of pollution. It is therefore key to prevent and resolve these kinds of disruptions, which requires knowledge on how they are caused, as well as on the transportation, detection and removal of pollutants.	Nanofabrication, Nanomaterial, Biomaterial, Nanoelectronics, Nanolithography, Self-assembly, Nano metrology and inspection, Materials by design, bio-nano devices for healthcare, defectivity, Contamination control, Deposition and coating technologies, Nanoscopy, Nano characterisation, Nano inspection.
	Nanomaterials	Nanomaterials are chemicals or materials composed of very small particles of different shapes and sizes (< 100 nm, including 2D materials). They occur in nature, but they can also be by-products of human activity (e.g. welding fumes) or be deliberately manufactured and manipulated to exhibit new characteristics, or to create surfaces with a specific structure. For example, nanomaterials can be used to increase a material's strength, chemical reactivity or conductivity. The fabrication of such materials and nanostructured surfaces requires tools and methods to make or grow them, and to inspect and characterise the materials at the nanoscale (see also nanomanufacturing). Computational methods are playing an increasingly important role in the development of new nanomaterials, for example in the creation of 'materials by design' based on the desired properties of the nanomaterials.	2D materials, Nano-coatings, Nanostructured (functional) surfaces, Nanoparticles, Nanotube, Nanosheets, Nanofluids, Nanorods, Nanofibers, Quantum dots, Electro-magnetic functionality (quantum materials), Nanocomposites, Nanocrystalline materials, Nanostructured films, Membranes, Bio-nano materials, Computational materials synthesis, High entropy alloys, Designer materials, Materials by design, Nanoscale meta-materials, Nanomaterials for neuromorphics, Nanotribological coating and structures, Colloids.
	Functional devices and structures (at the nanoscale)	Functional devices and structures (at the nanoscale) involves combining and integrating electronic, magnetic, nanomechanical, optical, bio or quantum principles to make components or devices that can manipulate matter at the atomic or molecular scale. The nanodimensions and material properties of these components and devices enable the creation of complex circuits and arrays.	Nanoelectronics, Spintronics, Nano-photonics, Nanoelectromechanical devices, Quantum-nanodevices, Semiconductor devices, Logic devices, Microelectronics, Micro- and nano mechanics, Molecular motors, Transistors, Nanoelectromechanical oscillators, Nanolithography, Neuromorphic nanodevices, Nanotribological coatings and structures.
	Microfluidics and nanofluidics	Microfluidics and nanofluidics comprises all techniques for studying, observing and controlling the transportation and reaction of fluids in micro- and nanoscale structures. Fluids in these structures behave differently than in macrostructures.	Nanofluidics Chips, Lab on a Chip, Organ-on-a-chip, Point-of-care bioanalysis, Nanofluidic devices, Bio-MEMS, Biosensors, Nanochannels, Nanoreactors, In-chip Nanocooling, Nanolithography.
	Nanobiotechnology / Bionanotechnology	Nanobiotechnology/bionanotechnology involves the application of nanotechnology to study life at the nanoscale, for instance to gain insights into cells and viruses. These insights can be used in medical applications, sensors, life-inspired materials and synthetic cells. Bionanotechnology is the application of molecular biology to nanotechnology to manufacture materials and devices at the nanoscale.	Drug Delivery, Tissue Engineering, Biocompatibility, Biosensors, Nanobiotechnology, Protein, Nanoscale, Nanoparticle, Nanomaterial, Biosensing, Cellular Biophysics, Biophysical Processes, Molecular biophysics, Nanoscale biomimicry, Biomimetic antibacterial surfaces, Biomolecule characterisation, Vaccine technology, Synthetic cell technology, Artificial meat.
Life science and biotechnologies	Biomolecular and cell technologies	Biomolecular technologies make it possible to map, measure and use molecules like DNA, RNA and proteins/metabolites. X-omics (genomics, transcriptomics, proteomics, metabolomics, glycomics, microbiomics, exposomics) are an important subset of biomolecular technologies. Their aim is to quantify and characterise all biological entities of a certain type, such as an organism's genome, proteome, metabolome, microbiome or exposome. This makes it possible to develop tailored therapeutic or disease prevention strategies (personalised medicine), or to grow crops or breed animals that are resistant to abiotic stress (for instance due to extreme climate conditions) and biotic stress (for instance due to diseases and pests). A second key group of biomolecular technologies are gene editing/precise genetic engineering techniques that allow the DNA of an organism (human, animal, plant, microbe) to be altered at very specific locations. A third group is stem cell technology (also known as regenerative medicine), which uses stem cells to promote the repair response of diseased, dysfunctional or damaged tissue. Another example of stem cell technology is crop regeneration, where a new plant is created from a single cell (for the purpose of propagation but also to eliminate plant viruses). Synthetic cell technology is emerging as a technique that mimics the structure and function of living cells from scratch (minimal cell) with the aim of increasing the yield and quality of a product and improving safety by preventing the formation of by-products. Great strides are also being made in the field of organoids: three-dimensional miniature versions of organs grown from stem cells.	Genome analysis, Genomic engineering, Multi-omics, Integrated omics, Biomarkers, Metabolomics, Transcriptomics, Proteomics, Glycomics High-throughput sequencing, Next generation sequencing, Machine learning, gene function prediction, Proteome/Genome/Metabolome analysis, Analytical chemistry, Exposome, Microbiome, Molecules by design, Cell Surface Display Techniques, Biomarker discovery. CRISPR-Cas, Single gene disorders, Ethics, DNA repair, Gene therapy, Genome editing, New Genomic Techniques, Precision Breeding, Synthetic Biology, Genetic Modification, Personalised medicine, Personalised food, Biofortification. Regenerative medicine, Organ transplantation, Tissue repair, Gene therapy, Targeted gene repair, Induced Pluripotent Stem Cells, In vitro Regeneration, Artificial cells, Minimal cells, Cell therapy, Synthetic biology, Metabolic Engineering, Organoids, Synthetic stem cells.
	Biosystems and organoids	There are various types of biosystems. In vitro systems – especially organoids – are playing an increasingly important role in the medical sector. Nanomedicine is the application of nanotechnology to benefit health, mainly through biochips and biosensors used in the diagnostic process or for the functional characterisation of complex (food) mixtures. Nanotechnology also plays a key role in organs-on-chips (OoCs): systems containing modified or natural miniature tissues grown in microfluidic chips used to represent either healthy or unhealthy human tissues. Other biosystem technologies are of interest in industry and for environmental applications, such as bioremediation. These include biosystems such as microbial consortia (gut, soil, etc.), aquatic plants, biofilms, symbiotic systems, and production systems using plants (vertical farms, algae).	Nanotechnology, Nanomaterials, Nanoelectronics, Nanofluids, Metabolic engineering, Bioreceptor, transducer, Analytes, Microfluidics, Biosensing, Lab-on-a-chip, Organ-on-a-chip, Microfluidics, Biosensors, Glucose Sensors, Immunosensors, Analytic Equipment. Organoids, Primary Cell Culture, Tissue Scaffolds, Bioprinting, stem cell technology, Microelectronics, Microfabrication, Organ and/or disease models, Personalised medicine, Patient-specific Modelling, Microbial consortia, Biofilms, Symbiotic systems.
	Biomanufacturing and bioprocessing	Biomanufacturing and bioprocess technology plays a key role in industrial and food biotechnologies that use enzymes and micro-organisms to make bio-based products. These technologies are used in the chemical sector, medicine production, the food and feed sector, healthcare, paper and pulp, textile biopolymers and bioenergy.	Microorganisms, Bio-based products, Bio-Based Building blocks, Biopolymer fibres, Biodegradable plastics, Biofuels, Lubricants, Industrial enzymes, Antibiotics, Vitamins, Amino acids and other fine chemicals, Pharmaceuticals,

		Bioprocess technology is mainly centred around biocatalysis: the use of natural substances, including enzymes from biological sources or whole cells, to accelerate chemical reactions. Much attention is also paid to optimising industrial production conditions for cultivation cells, culture systems and fermenters. Bioprocessing has important environmental applications as well and is used in wastewater treatment and other biological treatment technologies. Biofabrication, a rapidly developing high-tech branch of bioproduction, involves the production of complex biological products from raw materials such as living cells, matrices, plant biomass (including residual waste streams), biomass from fungi (e.g. mycelium from mushroom-forming fungi), biomaterials and molecules. The emergence of biofabrication is being driven in part by the development of 3D manufacturing technologies.	Vaccines or vaccine components, Diagnostics, Greenhouse gas emissions, Synthetic Biology, Metabolic engineering, Bio process technology. Protein Engineering, Organic solvents, Microorganism Biocatalyst, Superoxide Reductase. Biomaterials, fabrication, bioprinting, Tissue Scaffolds. Tissue Engineering, Artificial organs, Patient-specific Modelling, Cell Engineering, 3D biofabrication, 3D reconstruction, tissue constructs, biological models, regenerative medicine.
	Bioinformatics	Bioinformatics is the application of information sciences to biological processes. Recently, the field has received a major boost thanks to developments in machine learning and AI that make it possible to discover meaningful connections in very large datasets. AI will make it easier to expand our knowledge on the 3D structure of proteins, complex multigen processes in organisms, the risk factors and causes of diseases, the ways animals and humans respond to medical interventions or medication, and the ways crops react to different kinds of biotic and abiotic stress. Bioinformatics also aims to create an overview of allelic and phenotype variation, and to enable the analysis of complex networks, including non-biological and environmental (ecosystem) data.	Functional genomics, Structural genomics, Genome analysis, Genome-wide association studies, DNA Microarrays, Metabolome analysis, Medical Informatics, Systems biology, Artificial Intelligence, Machine learning, DNA/RNA/protein sequencing, Computational biology, Personalised medicine, Genetic diversity, Directed evolution.
Engineering and fabrication technologies	Sensor and actuator technologies	Sensors convert certain physical events into signals (e.g. electrical or optical). Actuators, on the other hand, convert electrical, thermal or optical signals into a physical action, such as turning or positioning a device.	Sensor networks, Actuator Networks, Optical fibre sensors, Ultrasonic sensors, Digital sensing, Internet of Things, Cyber-Physical Systems, Embedded Systems, Internet of Things, Digital Twin, Transducers, Molecular machinery, CRISPR-cas9 technology, Biotechnology, Bioengineering, Synthetic biology, Remote sensing, Plasmonics.
	Imaging technologies	Imaging technology is used to generate, collect, duplicate, analyse, modify and visualise optical and non-optical images. In the industrial sector, imaging technologies are mainly used for quality control. Combined with self-learning artificial intelligence, they also make it possible to detect problems more quickly. Imaging plays a major role in medical technology as well.	3D imaging, Vision in the loop (visual servo), THz and far-infrared imaging, Radio imaging, X-ray imaging, Optical and infrared, Medical imaging, Molecular imaging, Image-guided intervention, Tomography, Image reconstruction, Image processing, Image analysis, Machine learning, Plasmonics, Electron microscopy, Magnetic resonance, Astro imaging.
	Mechatronics and opto-mechatronics	Mechatronics involves the integral design of mechanical systems and associated control and regulation systems, combining mechanical, electrical and ICT engineering. Opto-mechatronics focuses on the integration of optical technology into mechatronic systems. Opto-mechatronic systems play an important role in semiconductor manufacturing, scientific instruments, medical devices and robotics.	Active and Adaptive optics, Multivariable and Robust Control, Adaptive algorithms, Smart Optics, Free-form optics, Wavefront sensing, Telescopes, Cameras, Spectrometers, Cryogenic temperatures, Computational optics, Topology optimisation for optics and mechanics, Plasmonics, Flat-optics for new imaging systems.
	Additive manufacturing	Additive manufacturing is the process of building a product layer by layer (3D printing). It is the opposite of subtractive manufacturing, where an object is made by removing material from a block (for example by chipping). Additive manufacturing includes materials development, process development and equipment development.	Bioprinting, Selective Laser Sintering, Stereolithography, Biofabrication, Computer Aided Manufacturing, prototyping, 3D metal printing, Print process qualification, 3D printing for biodegradables, for food and pharma.
	Robotics	Robotics is an interdisciplinary combination of computer science and engineering. The goal of robotics is to create intelligent machines that can assist humans in various ways.	Autonomous assembly and disassembly, Unstructured environment, Human-robot interaction, Self-configuration, Series of one, Customisation, Artificial intelligence, Autonomous systems, Soft robotic matter. Medical: Medical robotics, Surgical robots, Hospital robots, Rehabilitation robotics, Collaborative robots, Exoskeleton, Agro-food application, Pick and place, Drone systems, Social robotics.
	Digital manufacturing technologies	Digital manufacturing technologies are a key driver of productivity growth in manufacturing, building on systems and technologies such as cyber-physical systems, digital twins, ERP systems, robotics, and AI and machine learning. In the industrial sector, these are used to create digital representations of physical processes and systems to enable digital, scalable and flexible production. Driven in part by AI, digital twins are currently evolving into more autonomous, interactive and dynamic production systems. B2B platforms and data spaces are also important in this field, as is predictive maintenance.	Industry 4.0, Digital Technical intelligence, Real-time and Embedded Systems, Viable System Model, Embedded Systems, Cyber-Physical Systems (CPS), Cybernetics, Autonomous Systems, Computer Architecture, Predictive modelling, AR/VR, digital data spaces, Agent-based manufacturing, Predictive maintenance.
	Microelectronics	The field of microelectronics focuses on semiconductor components, as well as on highly miniaturised electronic subsystems and their integration into larger products and systems. It ranges from the production, design, packaging and testing of semiconductor components to microscale systems that integrate multiple functions on a chip (semicon devices). This technology also includes High Frequency and Mixed Signal Technologies, which bring together digital and analogue signals from different sources in an integrated system.	Electronic Transistors, Microchips, Semiconductor Diodes, Semiconductor Manufacturing, Semiconductor Detectors, Sensor electronics, Internet of Things, Medical electronics, Computing hardware, Signal processing hardware, 5G/6G, Biomedical biochemical sensors, GPS, communication, Radar, LIDAR.
	Systems engineering	Systems engineering is a methodical, multidisciplinary approach to the design, implementation, technical management, operation and decommissioning (design for recycling) of systems throughout their life cycle. It focuses on complex systems that comprise all the elements needed to optimise production and implement solutions: hardware, software, equipment, facilities, personnel, processes and procedures.	Complex systems, AI, Machine learning, Industrial engineering, Production systems engineering, Process systems engineering, Mechanical engineering, Software engineering, Electrical engineering, Cybernetics, Organisational studies, Project management, Power electronics, Knowledge-based engineering, Multi-disciplinary optimisation.